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THE CONSTRUCTION OF CONCRETE FENCE POSTS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF PUBLIC ROADS,
Washington, D. C., February 25, 1910.

SIR: I have the honor to transmit herewith a manuscript entitled "The Construction of Concrete Fence Posts." The fencing in of the rights of way may properly be considered a road problem. The growing scarcity of lumber and its constant increase in price have made it necessary to turn to new materials, and much success has followed the use of concrete for this purpose. I recommend that this manuscript be published as a Farmers' Bulletin.

Respectfully,

L. W. PAGE, *Director.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE CONSTRUCTION OF CONCRETE FENCE POSTS.

Many things have contributed to make concrete one of the leading building materials of the day. It has shown its worth as a substitute for wood because of its moderate cost, its durability, the ease with which it is handled, the wide distribution of sand, gravel, and stone which enter into its composition, and the tremendous growth of the cement industry. It has been thoroughly tried and tested, not only in laboratories, but also by years of actual use by the United States Government, by state agricultural colleges, by railroads and stock yards, and by hundreds of farmers, and it has, among other things, proved successful in the construction of fence posts.

COMPARATIVE ADVANTAGES OF CONCRETE AND WOODEN FENCE POSTS.

As a material for the construction of fence posts, concrete has not only very few of the disadvantages and practically all of the advantages of wooden posts, but it is also superior to timber in some respects. In the first cost concrete posts may be more or less expensive than the best wooden posts, according to the locality. This depends upon the timber supply, the deposits of gravel and rock, and the skill exercised by the person making the concrete posts.

If manufactured as usual and cured for three months, concrete posts are as good as the best wooden posts of the same size. After three years' service wooden posts possess only from one-third to one-half of their original strength, whereas concrete grows stronger with age and needs no repairs, for neither weather nor fire injures it. Under ordinary circumstances, good concrete posts will last forever; and even if a few, in the course of years, should be broken by unusual strains, it is cheaper to replace these than to replace an entire fence of decayed wooden posts with posts of material with the same lack of durability.

Concrete posts are attractive in appearance because of their uniformity of size and color and, because of their durability, they effect a saving in giving greater life to the fencing material used, so that the permanent value of the property is increased.

MATERIALS FOR MAKING CONCRETE.

SAND.

The sand to be used in making concrete must, above all things, be coarse and clean. Coarse sand, varying in the size of the grains, is generally clean and dense, and, therefore, produces a denser and stronger concrete than fine, light sand. Drift sand makes very weak concrete, while dirty sand weakens the mortar and often delays its setting. The difficulties encountered in making concrete are often ascribed to the cement, but more frequently they are due to the poor quality of sand. The presence of dirt in the sand is easily ascertained by rubbing a little in the palm of the hand. If a little is emptied in a pail of water, the presence of dirt will be shown by the discoloration of the water. This can be discovered also by filling a fruit jar to the depth of 4 inches with sand and then adding water until it is within an inch of the top. After the jar has been well shaken, the contents should be allowed to settle for a couple of hours. The sand will sink to the bottom, but the mud, which can be easily recognized by its color, will form a distinct layer on top of the sand and above both will be a clear depth of water. If the layer of mud is more than one-half inch in thickness, the sand should not be used unless it is first washed. Loam and clay may be washed out either on a wooden platform, a wire screen, or in an inclined V-shaped wooden trough. A small amount of clay in sand, for example, 5 per cent, does not decrease its value for use in cement mortar, provided that the clay is not in lumps. In fact, for mixtures lean in cement, the clay seems to add density and strength. Deposits of good sand are frequently found in stream beds.

GRAVEL.

Gravel, just as dug from the pit, is sometimes, though very rarely, found with the right proportions of sand and pebbles. The mixture best suited for concrete is two parts sand to four parts pebbles, in which all sizes less than one-fourth of an inch in diameter are considered sand. As there is generally too much sand for the gravel, it is advisable to screen the sand from the gravel by using a screen with a mesh of one-fourth of an inch and then to remix it in the proper proportions. All pebbles larger than 1 inch should be rejected. Gravel should contain no decayed stone and should be clean, in order that the cement may adhere to it. If dirty, it can be washed in the same way as sand. Valuable deposits of gravel are often to be found in stream beds, valleys, and at the foot of hills.

CRUSHED ROCK.

The best crushed stone for concrete is that which is clean and hard, which breaks with a sharp, angular fracture, and to which mortar easily adheres. Trap, granite, and limestone are among the best, while the use of shale, slate, sandstones, and very soft limestones should be avoided. The largest stones allowable in the manufacture of posts are those 1 inch in diameter.

Crushed rock should be screened only enough to remove the dust. The small particles are not a detriment, but a decided advantage, since they reduce the amount of cement mortar required and give to the concrete additional density and strength. However, in proportioning, small particles with a diameter less than one-fourth of an inch must be considered as sand.

CEMENT.

Kinds of cement.—There are two general kinds of cement on the market, natural (sometimes called Rosendale or hydraulic) and Portland. The processes of manufacture of both kinds are well known, and there are no patents to restrain anyone from engaging in their production. The several manufacturers put out many brands of each kind with special names, but all fall in these two classifications. With varying qualities, the principal ingredients of both cements are the same—silica, alumina, iron oxide, and lime. Natural cement, as the name implies, is a product direct from the earth, with the variations of nature in the proportions of its ingredients. It is burned to a moderately high temperature, and from the resulting clinker the finely powdered cement is ground. Portland cement, so named from its resemblance to the quarried stone of Portland, England, is a carefully proportioned mixture, with each ingredient measured to give the best results when combined with the others. The whole is ground to a powder, which is burned to a clinker at a very high temperature and again ground to the fine cement. On account of its uniformity, reliability, quick development of strength, and cheapness of cost, Portland cement has practically displaced the natural article on the market. Hereafter all reference to cement will mean the Portland variety only.

The scientific tests of cement are too complicated and too expensive for the small consumer. In selecting a cement he can do nothing better than to choose some well-known standard brand, guaranteed to meet the standard specifications of the American Society of Civil Engineers and the American Society for Testing Materials.

The retail price of cement is somewhat dependent upon the demand, the freight rates from the factories, and the quantity purchased. Price quotations are made with the barrel as the unit. Four sacks of 95 pounds each make a barrel of Portland cement.

Storage of cement.—Cement must be kept in a dry place, protected from the ground and out of danger of being wet by driving rains and moisture-laden drafts. The following is a very good method of storing cement. Upon the floor should be placed wooden blocks and over these a loose board floor. Upon this the cement is piled and then covered with a canvas or with roofing paper. Cement, once wet, forms lumps and is entirely unfit for use; but the lumps caused by pressure in the storehouse must not be mistaken for cement that has been wet and has then formed in lumps. Lumps caused by pressure are easily broken and the cement is perfectly good.

Water.—The last of the ingredients forming concrete is water, and any good-tasting drinking water is suitable for this purpose.

MOLDS FOR LINE POSTS.

Molds for concrete line posts are made of both steel and wood, and are built for single posts or in "sets" or "gangs." In deciding the size of the top and bottom of the post, and consequently of the mold, one should take into consideration the nature of the ground in which the post will be set. A very loose soil requires a post with larger ends and wider sides or a greater length for deeper setting in the ground. A careful observation of the smallest wooden post found satisfactory will help in deciding the size of the concrete post.

STEEL MOLDS.

The purchaser will find many patented steel molds on the market. It is advisable to buy a form simple in its general shape, for in such a mold the reenforcing can be placed more exactly where it belongs. Steel has some advantages over wood, since it is lighter, less cumbersome to handle, and gives the post a neater finish and any shape desired. Where the appearance is important, steel molds are to be preferred to wooden. Neighbors often club together, when this is desirable, in order to buy steel molds and so economize in this expense.

WOODEN MOLDS.

Wooden molds good enough for ordinary demands are very easily made. White pine is the best wood for this purpose, but at the same time it is the most expensive. Cheaper kinds of lumber, which are easy to work with, may be used. Molds made of 2-inch planks, dressed on both sides, form neater posts, but lighter lumber may be used, if the forms are well braced.

In imitation of the manner in which tree trunks grow, concrete posts are usually made tapering in size from butt to top. While this method may add a little to the appearance of the post and effect a slight saving in concrete, this saving is largely offset by the additional cost

of the carpenter's work and of the lumber used in making the molds. Theoretically, the tapering post has a better design than the one with straight sides, but for ordinary use one is as good as the other.

In making these molds, dressed lumber, planed from the rough, should be used. The proper dimensions for rough timber are 1 or 2 inches thick and 4, 6, 8, 10, or 12 inches wide; for dressed lumber they are $\frac{7}{8}$ or $1\frac{5}{8}$ inches thick and $3\frac{5}{8}$, $5\frac{5}{8}$, $7\frac{1}{2}$, $9\frac{1}{2}$, or $11\frac{1}{2}$ inches wide.

MOLDS FOR SQUARE POSTS.

Molds for posts that are square or nearly square in cross section are simple and easy to make. They are built in three patterns: (1) For posts without taper; (2) for posts tapering on two sides; and (3) for posts tapering on all four sides.

In order to avoid a sharp, irregular edge, neater posts are made by fastening a narrow strip of canvas or leather on the inside of the side board at the bottom of the mold, so that when the mold is put together and the concrete post molded the corner of the post will be rounded. A similar effect on the upper side of the post is produced by using a trowel or an "edger"—a special tool for rounding the corners of concrete walks or curbs. Clay plastered in the corner of the mold or wooden strips tacked to the sideboards will answer the same purpose. Such strips must, however, be as small as possible or else they will crowd out much concrete, and thus cause the reenforcement to be located too far within the post to obtain the best results. Ordinarily the reenforcement should be placed within three-fourths of an inch or 1 inch of the outside of the post.

For posts without taper.—The easiest and cheapest mold to make is the straight mold, or one for a post which does not taper. Such molds are merely long boxes built with various schemes for making the molding of the post a simple matter. On account of the amount of lumber saved and the ease with which these molds are filled, straight molds are generally made in "sets" or "gangs," by constructing several side by side with a continuous bottom and end pieces. Figure 1 shows the plan of a "gang" mold for making six posts, each of which is 7 feet long and 5 by 5 inches at both ends. On account of the rigid method of construction, all lumber used in this mold, with the exception of the 2 by 4 inch stringers, may be 1-inch dressed boards. The bottom is of 'ship lap" cut to the dimensions indicated on the drawing and nailed tightly to the three stringers. The end pieces (E) are made up of one board each to which are nailed blocks (B) 1 inch in thickness and 5 inches square, placed so as to allow the side pieces (S) to slip between them. The end pieces are hinged to the bottom with strap hinges (H), in which the fixed pin is replaced by a loose pin or a nail. This arrangement allows the end piece to be removed at will. Shutter hinges or loose

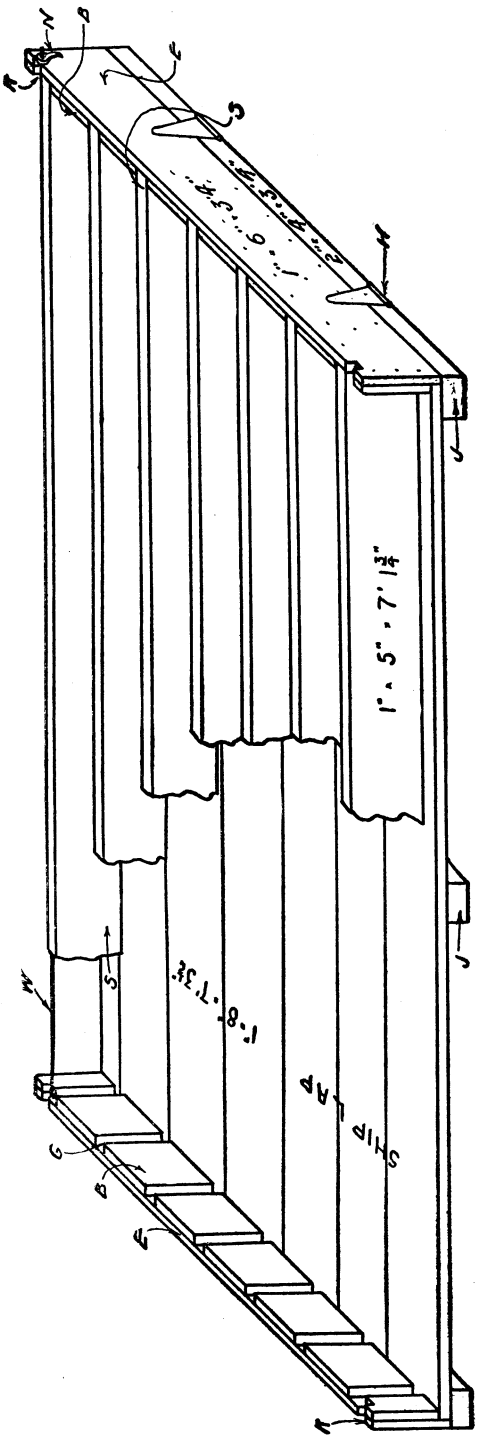


FIG. 1.—Gang mold for posts without taper.

pin door butts of heavy wrought iron may also be used as hinges. All the side pieces are alike and interchangeable.

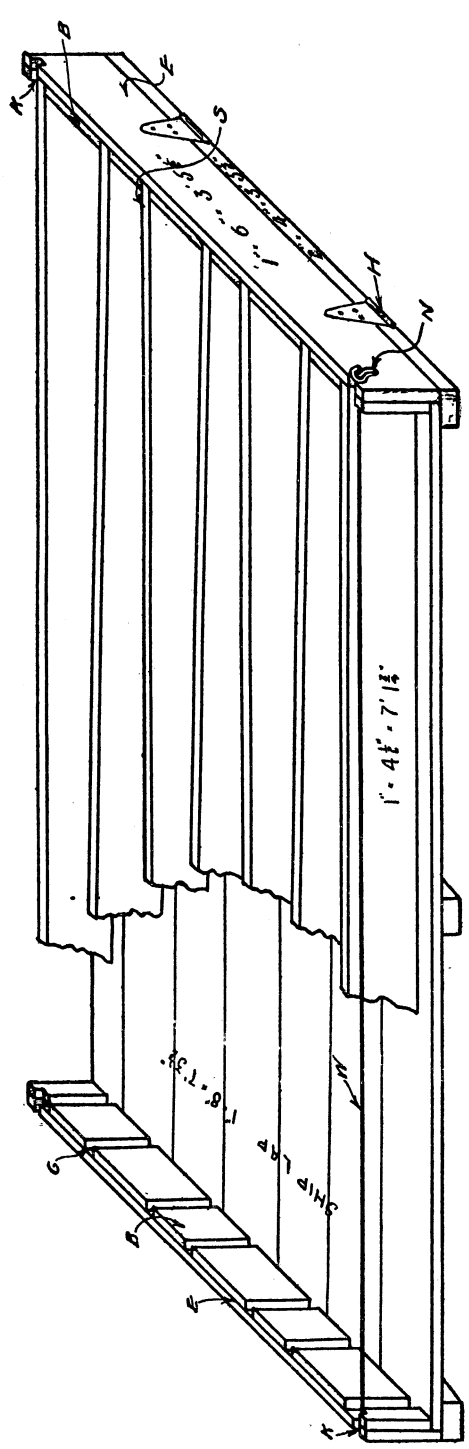
The form is set up ready for use in this manner. The end pieces are placed in position by inserting the loose pin of the hinges. Lengthened wagon rods (W), with crank nuts (N) at one end, are dropped into the slots (K), and the sideboards are then placed in the grooves (G) between the blocks on the end pieces. All the pieces are then drawn together by tightening the crank nuts (N). The slots for these rods should be faced with an iron strap and should be so centered that the rods, when tightened, will lie against the sides of the outer side pieces and act as stiffeners for them. With this arrangement, by merely loosening the crank nut on the end of the rods, when the concrete has sufficiently set, the end and side pieces may be removed without disturbing the posts and placed on a similar bottom board, and another batch of posts may be made. The first batch should be left on the bottom board, as will be explained later on pages 25 and 26.

By another method the end piece is hinged to the bottom like the end gate of a spring wagon bed, and the method of fastening is the same as generally used on spring wagons—spring elbow catches fastened with screws to the side boards and flush with them—so as to allow the concrete to be "struck" when the molds are filled. If the molds are constructed in this way, the outer sideboards should be made of 2-inch lumber.

For posts tapering on two sides.—Posts tapering on two sides are preferable to the straight posts in some respects. A satisfactory size for this style is produced in a mold 4½ inches deep by 6 inches wide at the butt, 4½ by 4½ inches at the top, and 7 feet long. These posts may be made more easily in gang molds, which are built so as to make the adjoining posts lie butt to top. By considering that the end positions of every post are reversed, it is possible to build this style of mold according to the directions set forth under straight molds. (Fig. 2.)[a] All dimensions for this mold should be taken carefully from figure 1.

For posts tapering on all sides.—Square posts are also made tapering on all sides. A line post of a satisfactory size may be obtained by making the molds 5 inches deep by 6 inches wide at the butt, 3 inches deep by 4 inches wide at the top, and 7 feet long. Since all the butts must be placed at one end and all the tops at the other, this arrangement causes the continuous bottom in figure 3 to be 1 foot wider at one end than at the other. The variation in the length of the sideboards and of the molded posts is, however, so slight (hardly one-fourth of an inch at the greatest) that no attention need be paid to it

[a] The letters indicating the various parts are the same as used for straight molds and in the paragraph discussing them.



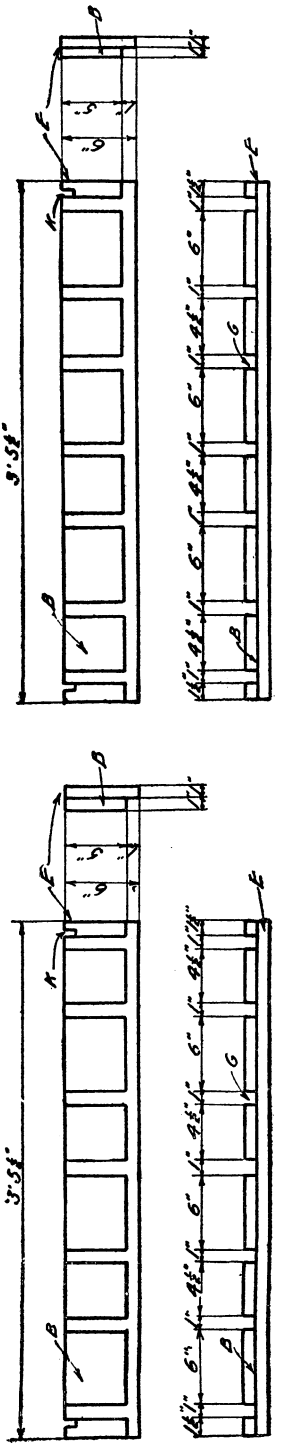


FIG. 2.—Gang mold for posts tapering on two sides.

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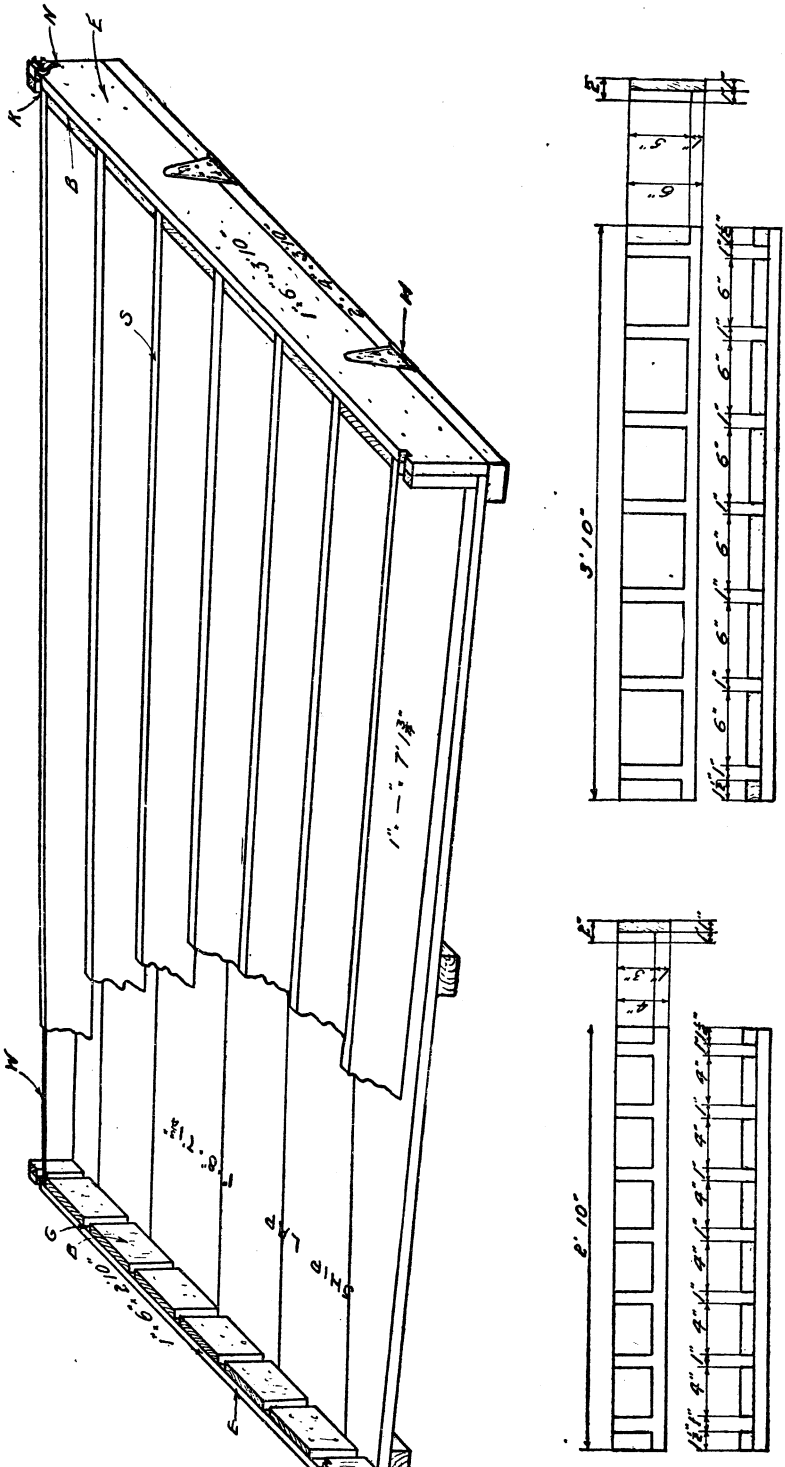

FIG. 3.—Gang mold for posts tapering on all sides.

and all sideboards can be made the same length. The construction of the mold will easily be understood from figure 3, and from the description of the end pieces, with the manner of hinging and fastening them to the side pieces, as given under straight molds. All the dimensions for this mold must be taken carefully from figure 3.

MOLDS FOR TRIANGULAR POSTS.

Triangular molds without a taper are easily constructed in "sets" or "gangs." On account of their shape, they may be braced at any point and, as a result, 1-inch boards may be used in their construction. In figure 4, molds for three sizes of triangular concrete posts are shown. The two boards are hinged together at the ends and quarter points on the bottom by ordinary 3-inch wrought-iron strap hinges bent to conform to the shape of the mold and fastened with $\frac{3}{4}$-inch screws.

Sharp corners on the finished post are somewhat objectionable, on account of their roughness and sharpness, and the possible waste of material. This undesirable feature is avoided by placing a wooden tongue or strip (T) in the bottom of the form, as shown in figure 4, and by rounding the corners at the upper face either with a trowel or an edger (see p. 9).

The manner of supporting and bracing the gang triangular mold is shown in figure 5. Three 2 by 4 joists (J) should be cut with each 4 feet $8\frac{3}{4}$ inches in length. Beginning at either end, $3\frac{5}{8}$ inches should be laid off for the cleated lock piece (P) made of a 2 by 4 inch board with cleats of strips 1 by 2 by $3\frac{5}{8}$ inches. The lock piece laid under the joists, as shown, serves to bind them together. Then $1\frac{1}{2}$ inches should be marked off for the strip (U) on the end board, 3 inches for a half brace block (b), and afterwards $1\frac{3}{4}$-inch openings for the insertion of the hinged sideboards (S) and 6 inches for the full brace blocks (B), until six posts are provided for, with a half brace block, strip, etc., at the other end. The brace blocks (B) are cut from scantling 2 by 6 inches. They are $5\frac{1}{2}$ inches deep, and are 2 inches wide at the top and 6 inches at the bottom, where they are nailed to the joist (J).

The ends (E) for the molds are made from 1 by 10 inch boards and are 4 feet $1\frac{1}{2}$ inches long. They are fastened, at the bottom side, to the joists (J) by means of heavy, loose-pin wrought-iron strap hinges, shutter hinges, or door butts (H), and at the upper side with wagon rods (W) and wing nuts (N) or with elbow catches (see also fig. 3). Until all of the molds of the gang are partially filled with concrete, it is sometimes necessary to keep them from spreading open at the center by using a tie brace made from a 2-inch board with blocks of 1 inch in thickness attached so as to fit the molds when the brace is in place.

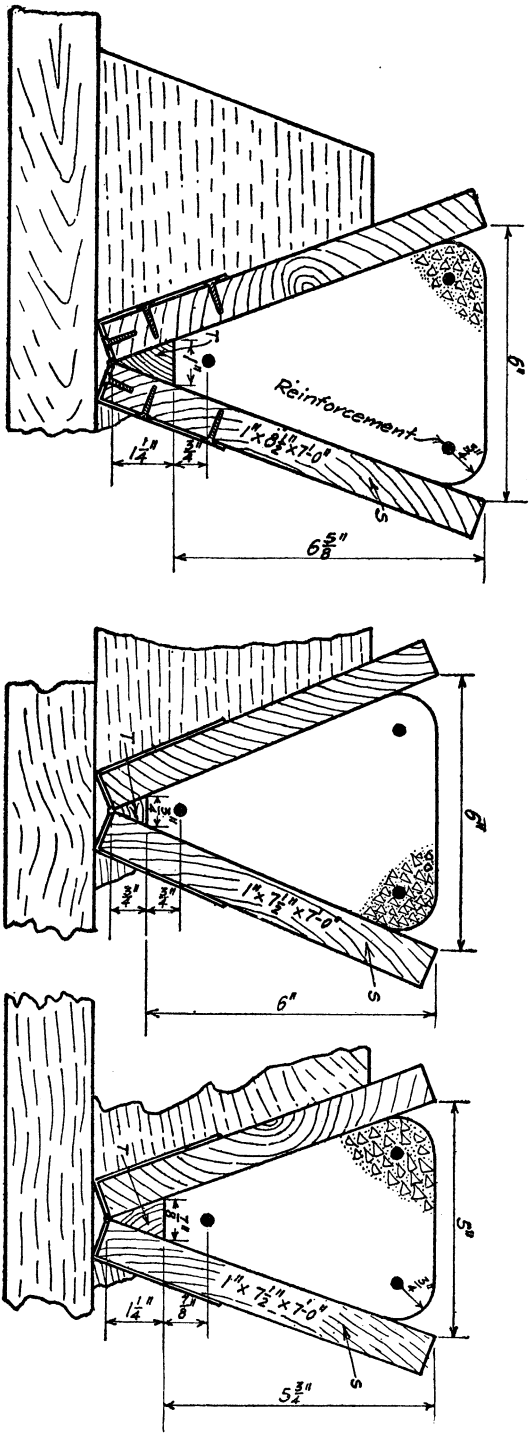

FIG. 4.—Molds for triangular posts.

With slight changes, similar forms may be built for medium and light posts. Triangular posts tapering on all sides can be built,

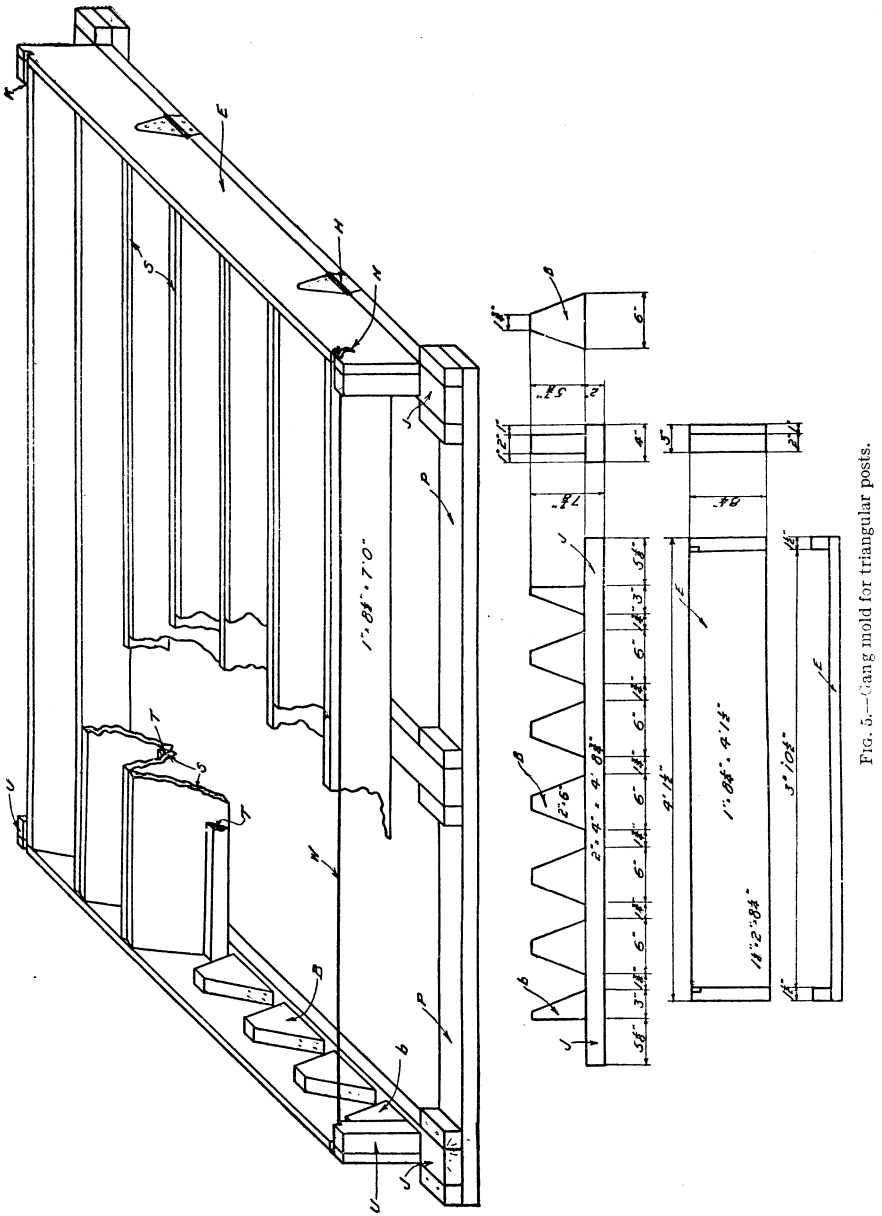

FIG. 5.—Gang mold for triangular posts.

but the molds are difficult to construct, and the amount of material saved is not worth the trouble.

OILING THE MOLDS.

Concrete has a tendency to stick to either steel or wood. In order to yield a smooth finish to the post, it is customary to give the inside of the molds a coating of oil. Soft soap or crude oils used sparingly serve the purpose well. Too much oil will destroy the setting qualities of the cement and will give a face roughened with pockmarks. A small amount of oil, poured into a pail of water and applied with a mop or stiff broom in scrubbing out the molds after they have been used five or ten times, or as often as necessary, will prevent the concrete from sticking.

REENFORCEMENT.

PRINCIPLES INVOLVED.

Concrete and steel render valuable assistance to each other in the support of heavy burdens. On a solid foundation, loaded from above and thus under direct pressure, a concrete column will withstand the strain of an enormous load. A much smaller load so placed as to cause stretching or bending toward one side of the same column may cause it to snap off, for concrete is strong, but brittle. On the other hand, steel is tough and elastic. In the form of rods or wire, steel withstands massive loads that tend to stretch it, and thus displays a kind of strength directly opposite to that of the plain concrete column. In modern construction these two valuable properties of concrete and steel are utilized by combining them in what is called reenforced concrete. With steel properly buried in the concrete, the column withstands not only the load which might otherwise snap it, but one many times larger and even though it is applied at any place along its length.

Reenforcement, therefore, is steel in the form of bars, rods or wires, buried in concrete to take up and to withstand the strains which tend to stretch or to bend the concrete. A concrete fence post is merely a small concrete column. Reenforced, it easily stands the strain from usage in a fence line.

The value of reenforcing concrete posts properly may readily be seen from figure 6. If a load (L) is raised so that its weight is supported on one side by a wooden post, the post will bend, as in figure 6. The fiber in the wood on the side away from the load may be tough and elastic enough to prevent the post from breaking, and when released the post will spring back into its former position. In the third figure a No. 9 wire (W) is fastened securely to the wooden post at the top and at the ground surface, and is supported along its length by the struts (S). If the same load is applied, the post will not bend, because the wire takes up the bending or stretching strain.

This is precisely the case with the reenforcement in a concrete post. Supported along its length by the concrete, the wire (W) or steel in other shapes takes up the bending or stretching strains. Since the load which causes bending or stretching may come from any direction, concrete posts are reenforced on every side; otherwise they might break in a manner somewhat similar to that in which the wooden post bends when the reenforcement is not on the proper side of the post.

In the effort to be safe it is a common fault to insert more reenforcement than is absolutely necessary. This adds needlessly to the cost of the post, for concrete posts become stronger as they grow older.

KINDS OF REENFORCEMENT.

With regard to the roughness of the outside, metallic reenforcing materials are divided into two classes, smooth and corrugated or

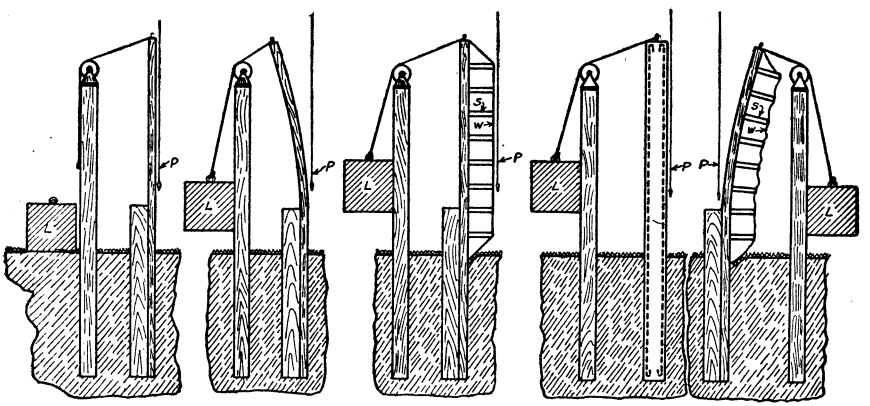

FIG. 6.—Showing effect of reenforcement.

deformed. The general result of the many tests carried on in testing laboratories seems to indicate that in strength of bond, if the concrete is sufficiently rich and well mixed, smooth surfaces give satisfactory results. Two kinds of reenforcement are much used—bars and wire.

Bars.—Round bars three-sixteenths or one-fourth of an inch in diameter are the size and kind most used in posts. The stock on hand at blacksmith shops and hardware stores is generally from steel that stretches too easily and therefore is not the best for reenforcement. Companies which make a specialty of reenforcing materials can furnish both rods and bars which stretch only under very large loads.

Wire.—The development of the wire fence has produced a material well suited for reenforcing purposes. Of equal size, such wire will produce a stronger post than the material described above. Single

No. 8 or two No. 12 wires twisted are sufficiently strong as reenforcement for ordinary line posts. In order to obtain straight wire of the necessary length, the coils ordinarily placed on the market should not be straightened out. Straight wire can be obtained from dealers in the same manner as baling wire; that is, either single or twisted into two or three ply cables and of the length desired. The plain, ungalvanized fencing wire is the proper kind, for galvanization adds nothing to the strength and the metal will not rust when incased in the concrete.

The following table will be convenient in determining the size and weight of wire desired for reenforcement or for other uses:

Sizes and weights of wire.

Gauge.	Feet to pound.	Gauge.	Feet to pound.	Gauge.	Feet to pound.	Gauge.	Feet to pound.
1	4.68	6	10.17	11	25.82	16	95.98
2	5.44	7	11.97	12	33.69	17	128.6
3	6.31	8	14.29	13	44.78	18	166.2
4	7.38	9	17.05	14	58.58	19	223
5	8.75	10	20.57	15	72.32	20	309.6

The "fool-proof spacer."—In order that the reenforcement may be placed and kept just where it belongs, there is in use a little device called the "fool-proof spacer." It consists of a No. 10 wire, cut to such length that, when twisted once around each of the two reenforcing wires or rods, the ends will nearly touch the sides of the mold (fig. 7). The distance from the twist to the end of the short wire is equal to the distance from the reenforcement to the side of the mold. In triangular molds such a spacer can be used only on the two rods or wires near the top of the mold. A shorter and similar device, with only one twist, may be used on the lower reenforcement. At least three spacers should be placed on each piece of reenforcement.

Spacers on No. 8 wire, which should be placed three-fourths of an inch from the inside of the mold, should be made from the following lengths of wire for the various sizes of triangular posts:

Length of wire for spacer (in inches) for triangular posts.

	Heavy posts.	Medium posts.	Light posts.
Upper spacer	$6\frac{1}{2}$	$6\frac{1}{2}$	$5\frac{1}{2}$
Lower spacer	2	2	$1\frac{3}{8}$

Spacers on No. 8 wire for various sizes of square, or nearly square, posts should be made from the following lengths of wire:

Length of wire for spacer (in inches) for square posts.

	Straight posts—5 by 5.	Posts tapering on two sides—4½ by 6, 4½ by 4½.	Posts tapering on four sides—5 by 6, 4 by 3.
Bottom spacer	5½	6½	6½
Middle spacer	5¾	6	5½
Top spacer	5¾	5¼	4¾

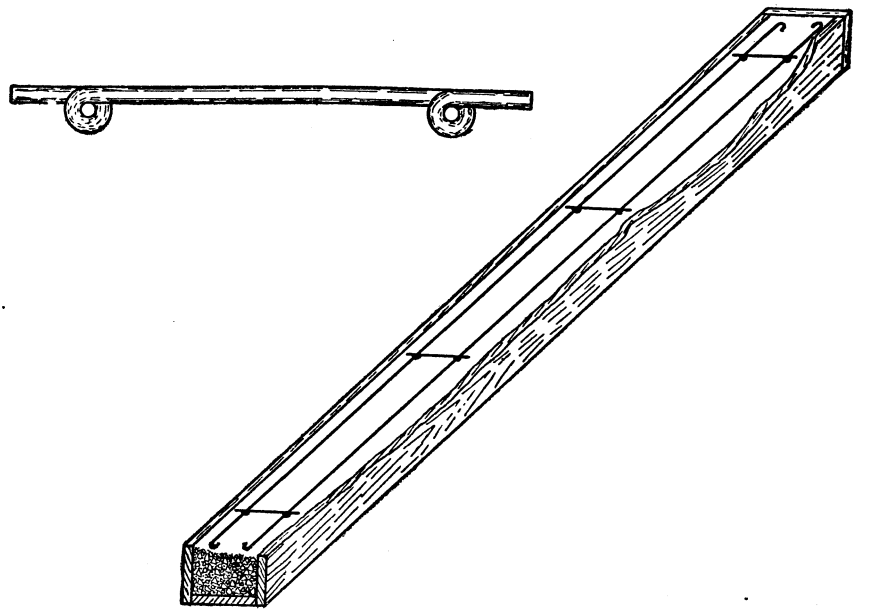

FIG. 7.—"Fool-proof spacer" for reenforcement.

For larger or smaller reenforcing a little additional length may be added or deducted. When the proper length has been determined, a number of spacers should be prepared and slipped on the reenforcing iron by way of preparation for placing it in the mold. This serves to hasten the work.

GENERAL REMARKS.

Reenforcing should be placed near the outside wall, where it is reasonable to expect that cracks will open. For reenforcement, metal slightly rusted is as good as metal that is not rusted, if not better. In placing the reenforcing rods in position it is a wise precaution to bend them back at the ends (fig. 7). This takes only a little more time, but, if it is done, the reenforcement must be 2 inches longer to

allow the metal to be turned back 1 inch at each end of the post. New barbed wire should not be purchased for reenforcement, for, while it costs more than plain reenforcement, the bond between it and the concrete is no stronger than between smooth wire and concrete. The danger section, or the point where posts are liable to break, is at the surface of the ground. For fences for lots and other places where posts may be subject to rubbing and crowding, short extra reenforcing pieces 2 feet long are sometimes placed in the post to lap this danger section. The corner of triangular-shaped posts which is not nearest the fence wire should, in theory, have heavier reenforcement than either of the other corners. If rods three-sixteenths of an inch in diameter, No. 8 wire, or two twisted No. 12 wires, are used in the other corners, a rod one-fourth of an inch in diameter, or two or three twisted No. 12 wires, should be placed in the threatened corner.

THE CONCRETE.

APPLIANCES USED IN MIXING.

The mixing board.—The size of the mixing board depends on the number of men employed in this work and on the amount of room available for placing the board in position. Sometimes a tight and even floor in a building may be used. The steel sheet from the platform of an old self-binder may be used for a mixing board, but the larger the board the more convenient it is. For two men mixing, the board should be 8 by 12 feet; for four men, 14 by 14 feet. The first size is usually large enough for making posts. It should be built of matched inch boards, free from knots, drawn tightly together and placed the short way of the platform, so that the mixers may shovel with the cracks and not against them. The framework should consist of four scantlings 2 by 4 inches, laid the long way, and with the two outside ones of sufficient length to afford handles for carrying. The location for the board should be fixed before the sand, stone, and gravel are unloaded. A level spot with sufficient open space convenient to the work and, if possible, near the water supply should be chosen. Much hard labor can be saved by locating the mixing board lower than the water tank and by siphoning the water through a garden hose to a barrel or other receptacle at the mixing board. The board should be raised on blocks until it is level, so that under the weight of concrete it will not sag in the middle. If water is added gradually, as it should be, there will be little liquid grouting to run. It is best, however, to nail a 2 by 2 inch strip or a piece of 2 by 4 inch scantling around the edges of the board.

Runways.—If, in wheeling the materials, runways are necessary, they should be built so that they will be smooth and strong. Should

the runs be over 2 feet above the ground, 20 inches is none too great for their width. The speed of the work depends upon the rate of moving the materials and concrete.

Tools.—One great advantage in using concrete is that it can be made with the investment of very little money in special tools. If the few required are not already at hand for other purposes, the new ones will serve in many different lines after the concrete is finished. For mixing, it is necessary to have from two to four square-pointed, short-handled "paddy" shovels, size No. 3. A couple of wheelbarrows with steel trays and with a capacity of 2 cubic feet are convenient for moving the sand, stone, and concrete. If wooden molds are used, a metallic sidewalk "edger," with a curve of three-eighths of an inch in the radius, will make neat corners. A corner trowel, or even an ordinary trowel, will answer the same purpose fairly well. Screens may be made by nailing ¼-inch and ½-inch mesh wire screening, 2½ by 5 feet, to frames made of 2 by 4 inch lumber.

The measuring box.—Since construction with concrete is so easy, many persons are careless about the exact proportions of the cement, sand, and gravel or crushed rock to be used in its composition, but this is a very important point. The bottomless box with handles attached is a very useful article for this purpose. For posts, a convenient measuring unit is a box with an open bottom 12 by 14⅜ and 10 inches deep, measured on the inside. This box, filled to the top with the loose material and smoothed level, contains practically 1 cubic foot. The inches in height may be marked with brass tacks. Then, since each inch in height represents one-tenth of a cubic foot, the measurements are easy. If, on account of its size, the use of this box would be too slow for measuring the sand and gravel, larger boxes or wheelbarrows may be gauged and used, or other boxes may be made on the same principle. It is a very poor practice to count shovelfuls, as it produces unsatisfactory and even dangerous results.

MIXING A SIX-POST BATCH.

The following table gives approximate quantities for a batch of concrete sufficiently large to make six posts 7 feet long and of the sizes named in the table. The quantities may be increased in like proportion and any desired number of posts may be made. The first of the two lines of figures given for each of the three grades, heavy, medium, and light, indicates the proportions to be used when the sand is screened from the gravel. The second line gives the proportions when "bank-run" gravel is used; that is, gravel dug directly from a bank without screening the sand. In this case 1 part of cement to 4 parts of the mixture of sand and gravel should be used.

Quantities of material and resulting amount of concrete for a six-post batch.

TRIANGULAR POSTS—LENGTH, 7 FEET.

Size of post.	Proportions of materials by parts, measured in volume.			Materials in cubic feet, measured loose.			Concrete tamped, cubic feet.	Water for mixing, gallons.
	Cement.	Sand.	Gravel or rock.	Cement.	Sand.	Stone or gravel.		
Heavy	1	2	4	1.4	2.8	5.6	6.2	11
	1	.....	4	1.5	.....	6.0	6.2	11
Medium	1	2	4	1.3	2.6	5.2	5.5	10
	1	.....	4	1.4	.....	5.6	5.5	10
Light	1	2	4	1.1	2.2	4.4	4.8	9
	1	.....	4	1.2	.....	4.8	4.8	9

RECTANGULAR POSTS—LENGTH, 7 FEET.

Straight, 5 by 5	1	2	4	1.7	3.4	6.8	7.3	13
	1	.....	4	1.8	.....	7.2	7.3	13
Taper on two sides, $4\frac{1}{2}$ by 6, $4\frac{1}{2}$ by $4\frac{1}{2}$	1	2	4	1.6	3.2	6.4	6.9	12
	1	.....	4	1.7	.....	6.8	6.9	12
Full taper, 5 by 6, 4 by 3	1	2	4	1.5	3.0	6.0	6.7	12
	1	.....	4	1.6	.....	6.4	6.7	12

PROPORTIONING THE INGREDIENTS.

On account of the variations in the size of the sand grains and in the unfilled spaces between the particles of sand, stone, and gravel, the quantities of concrete made according to the proportions above may be greater or less than those stated in the tables. For the same reason the quantities of water may or may not be sufficient to make the concrete wet enough. Such matters, with the experience gained through making a few batches, may be easily adjusted. Water should always be measured by the bucket to have uniform results.

Different pockets of sand and gravel and different "crusher-run" rock vary in size and consequently in the unfilled spaces or voids between the grains or pieces. This variation, in theory, calls for varying quantities of cement, but the methods of determining the exact amount of these unfilled spaces are so complicated and so open to mistakes that, with cement at its present low price, it is cheapest in the long run to adopt proportions or mixtures which are rich enough to guarantee a well-made, strong post. If unscreened "bank-run" gravel is decided upon, it should be used in the proportion of 1 part of cement to 4 parts of gravel. For crushed rock or screened gravel (which is much better than "bank-run" gravel), the concrete should be used in the proportion of 1 part of cement, 2 parts of sand, and 4 parts of rock or gravel. All measurements should be made with the material poured loosely into the measuring box, and the box, when full, should be leveled smooth.

The amount of moisture in the sand, gravel, and stone varies so much with weather conditions that the quantity of water for a cubic foot of concrete can not be fixed exactly. During the mixing of

the cement with the sand and rock, sufficient water should be used for the concrete to be wet enough, when the mixing is complete, to tremble under a blow from the shovel and to run into the molds. This amount of water causes a rich mortar to flow to the outside of the post and insures a smooth finish. A force pump and hose afford a convenient means of conveying water to the work. Often by locating the mixing board lower than the water tank, water may be siphoned through a garden hose to the board.

MIXING "BANK-RUN" GRAVEL.

For concrete from unscreened "bank-run" gravel, one-half of the amount of gravel required for a batch of posts should be spread out in oblong shape; and upon this should be evenly distributed, first the full amount of cement, and then the remainder of the gravel. Two men facing each other and at the same end of the batch (and, if necessary, two at the other end), with square-pointed "paddy" shovels, turn the dry cement and gravel with a "flopping," dragging stroke. By timing their strokes, the mixers can cause their shovels to meet regularly at the middle, which insures the complete mixing of all the materials. For a thoroughly mixed concrete, no definite number of turnings can be fixed, but the shoveling should be continued until the cement no longer shows in streaks or until the mixture has a uniform color. Skillful concrete turners do not lift the shovel from the board and "flop" over its contents as though they were turning "flapjacks," but by gradually turning the shovel and at the same time dragging the stroke, they completely mix the dry cement and gravel in two turnings. When the scattered materials around the edges have been thrown upon the pile, it is cut open and, using a sprinkler—a sprinkler bucket or a hose with spray attachment—about three-fourths of the water required is added. Water dashed from buckets or from the ordinary nozzle of a hose causes a waste of cement. The mixture is again turned and cut open as before. Then the remaining one-fourth of the water is added and the mixture is turned again. With careful workmen, the concrete should now be well mixed; but, if it shows dry spots, it must be turned once more. After this the concrete should be shoveled into a compact ridge, ready to be wheeled away to the molds or to be shoveled into them. The mixing board should be thoroughly cleaned at the close of each day's work. Persons who intend to make the manufacture of posts a business will do well to invest in a good power mixer.

MIXING CRUSHED ROCK OR SCREENED GRAVEL.

In general, where crushed rock or screened gravel is used, the mixing is very similar to that of "bank-run" gravel. The full amount of sand is spread out upon the board and upon it the necessary

cement is evenly distributed. The whole is turned dry until the cement no longer shows in streaks and the color of the batch is uniform. The mixture is then spread out flat, just as the sand was, and upon it the crushed rock or screened gravel is distributed evenly. Three-fourths of the required water is added and the mixing is continued as for mixing "bank-run" gravel. In dry, hot weather it is a good plan to throw water on the pile of crushed rock before mixing.

CONCRETE POSTS.

MOLDING.

After the molds, which, as a rule, lie flat, have been oiled or soaped, the concrete should be placed in them at once. If, for any reason, the concrete stands thirty minutes after mixing, it should be thrown away and a new batch mixed, for cement, if it has once partially set, makes weak, dangerous concrete, even though it is retempered by turning or adding water. After the molds are filled evenly to the depth of three-fourths of an inch or 1 inch, according to the spacing of the reenforcing rods or wires, the reenforcement should be laid in, properly spaced by means of at least three "fool-proof" wire spacers. The concrete should then be poured in until the molds are filled within three-fourths of an inch or 1 inch of the top, when the remaining reenforcement is fitted in place in the manner described above and the molds are completely filled. To render the concrete more compact, a crowbar or a pinch bar should be placed under each corner of the mold successively and moved up and down quickly. This vibration makes the concrete more compact by shaking out the air bubbles, but there will be very few of these bubbles if the concrete is sufficiently mixed to proper consistency. If desired, the exposed corners of the post may be beveled with an "edger" and the open face given a neat finish by using a trowel immediately after the surface water has been absorbed and before the concrete has become too hard.

If wooden molds are used, they should be well soaked in water, so that the green concrete will not cause them to swell and thus crack the posts.

The wind, the hot sunshine, and the frost are destructive to concrete; and, while it is an easy matter to protect the post from the first two agents, it is best to do no concrete work when the thermometer is below the freezing point, unless inside a building.

CURING.

It is a great mistake to believe that, when the molding is done, a concrete post is finished. The quality of the post must be determined by curing. The green post should be left in the mold until thoroughly hardened; that is, usually for two or three days. For square

or nearly square posts the molds proper may then be removed and used on another bottom board, but the posts must stay on their bottom board in the shade and must not be disturbed for at least a week or ten days. Posts in triangular molds may be carried out, each in its own mold, after from five to seven days, and the post may be gently slid from its mold to a smooth floor covered evenly with a cushion of sand. While green the strain of lifting, or even a slight jar, will cause cracks, sometimes invisible, which greatly weaken the post. During the first two days of the life of a post it must be kept wet and covered with canvas, burlap, carpet, or any clean material. Sand will serve after the concrete has become hard, but manure will stain green concrete and otherwise affect it. The sprinkling should be continued up to the eighth day. After the tenth day, if the space is needed, the post may, with care, be placed on end in the same manner that wooden fence rails were formerly piled. A drop of only 6 inches often breaks a green post. The jar in hauling to the field over rough, frozen roads or in a wagon bed with a very uneven bottom has seriously injured posts which were not well seasoned. Concrete posts gain rapidly in strength for the period of one year; they should, therefore, be made as long as possible before it is necessary to set them in the fence. No post should be used until it is at least 3 months old, and, to meet any contingency, a supply of well-seasoned posts should be kept on hand.

BUILDING THE FENCE.

SETTING THE POSTS.

Experience has taught that with regard to stringers and joists, in order to get the greatest strength from the timber, one should place the beam with the narrow side against the load and with the depth extending in the same direction as the pressure. Likewise, posts should be placed so that the narrow side will support the wire. This will give the greatest resistance to breakage from animals rubbing against them or trying to get through the fence between the posts. The depth to which posts should be set varies with the character of the soil. Seven-foot posts are usually set from 2½ feet to 2 feet 8 inches deep. The earth about the post should be thoroughly compacted by tamping.

METHODS OF ATTACHING WIRE.

There are numerous methods of attaching wire fencing to concrete posts. Some makers place staples or wire loops in the green concrete; others make holes in the posts. The former method is not desirable because the fastener can not be located exactly where the wire of the fencing will come when the post is set in the ground; then, too, the fastener will eventually rust or break off and will thus injure

the looks of the post. On the other hand, holes through the posts weaken them and therefore this method is, in general, unsatisfactory.

The simplest, easiest, and cheapest way of fastening a wire fence to a concrete post is by encircling the post with a wire one size less than the corresponding wire in the fence proper and by twisting this wire around the strand of the fence. This is done in two ways. The fastening wire is placed around the post, twisted upon itself and then to the fence wire; or one end of the fastening wire is twisted

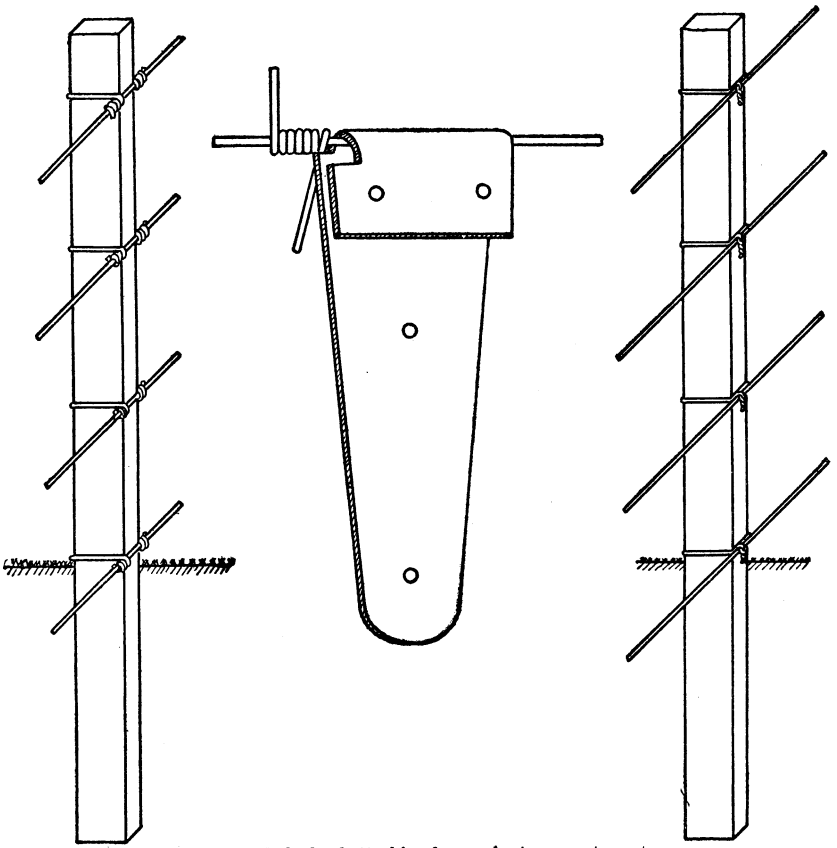

FIG. 8.—Methods of attaching fence wire to concrete posts.

around the fence wire, and the free end is then carried around the post and twisted on the other side to the same wire. (Fig. 8.) The latter method is known as "the Western Union twist." Either plan is good, but care must be taken to draw the fastening wire tight, or else stock trying to get through the fence may raise or crush down the fencing with their heads. If any trouble is experienced, the post should be roughened at the fastening point with a cold chisel.

Expansion and contraction of the fence due to heat and cold are cared for by the tension curves or "kinks" in the woven-wire fencing,

and no fear may be felt in drawing the fastening wires as tight as necessary. Wooden nailing strips should never be embedded in the posts, for moisture will swell the wood and crack the concrete.

STRETCHING THE FENCING.

Good tools for stretching wire fencing may be found in almost any fence company's catalogue. Stretchers should be such as to be easily operated by one man. They usually consist of two heavy chains, one of which is fastened to a post at the corner or brace in the fence and the other by means of a large hook to the wooden clamp which holds the loose fencing. The stretcher proper, operated by a lever, is the connecting link between the chains. By working the lever back and forth, dogs reach out, grasp, and draw in link after link of the chain, and thus tighten the fence. The best stretchers are also automatic in releasing the wire. Owing to the great force used in stretching fencing, it is advisable from the standpoint of safety to purchase stretchers with automatic releases. There are many good automatic single-wire stretchers on the market.

LINE ANCHORS.

Concrete posts, by their weight, serve to hold fences down in the gullies of hill country. Sometimes in such places and occasionally under other conditions the wire fencing must by some means be staked to the ground to prevent small animals from going under it. This may be accomplished either by digging a hole under the fence, filling it with concrete, and embedding a tie wire in the concrete, or by burying a block of concrete around which the tie wire has been placed. After the concrete has set, the fence may be made secure by attaching the tie wire to the heavy lower wire of the fencing.

COST OF CONCRETE POSTS.

So many elements enter into the matter of cost that no exact figure can be given. The prices of labor, molds, cement, sand, stone, gravel, reenforcement, and lumber are not the same in any two sections of the country. The cost of only two sizes of post will be considered here—the heavy, triangular and the straight, square post, each of which has a standard length of 7 feet. The figures are based on the following data: A mixture of 1 part of cement, 2 parts of sand, and 4 parts of crushed rock or screened gravel; a reenforcement consisting of two No. 12 smooth fencing wires twisted into a cable and cut to the necessary length at the factory; concrete mixed by hand; all materials delivered at the work, and all labor of men and teams paid for.

With the heavy, triangular post, if considered necessary, a slightly heavier reenforcement may be used in the corner of the post away from the fence.

Cost of materials and labor and of the finished posts.

HEAVY, TRIANGULAR POSTS.

Materials.	Cost.	Number of posts.	Cost per post.
1 yard of rock or gravel	$1.00	29	$0.03½
1 yard of sand	1.00	58	.01½
1 barrel (4 sacks) of cement	1.50	18	.08½
3 two-ply No. 12 wire cables (weight, 1¾ pounds)	a.02½	1	.04½
2 men for one hour, at 20 cents per hour	.40	5	.11
1 boy for one hour, at 15 cents per hour	.15		
Total cost			.29

STRAIGHT, SQUARE POSTS.

1 yard of rock or gravel	$1.00	25	$0.04
1 yard of sand	1.00	50	.02
1 barrel (4 sacks) of cement	1.50	16	.09½
4 two-ply No. 12 wire cables (weight 2¼ pounds)	a.02½	1	.05¾
2 men for one hour, at 20 cents per hour	.40	5	.11
1 boy for one hour, at 15 cents per hour	.15		
Total cost			.32¼

a Per pound.

Since the straight, square post is slightly larger than the heavy, triangular, it costs a little more.

MISCELLANEOUS POSTS WHICH MAY BE MADE OF CONCRETE.

Concrete posts are used for many other purposes than line posts. The sizes are slightly different, but the principles and general lines of design are the same.

CORNER POSTS.

Corner posts are generally made with square ends, 8 by 8, 10 by 10, or 10 by 12 inches, and without taper. Heavier reenforcement is used and should be increased in amount by placing extra pieces on all four sides either at the middle or one-third points. The wire may be drawn around the post or holes may be made through it by placing greased iron rods at the proper places in the green concrete and turning them about occasionally so that the concrete will not set to them. A short piece of pipe may be placed through the mold and left in the post in order to provide a hole. Through these holes the strands of wire may be stretched and some tightening device may then be used. The post should be thoroughly cured before being strained by holding a tightly stretched fence.

BRACING POSTS AND BRACES.

Bracing posts should be placed frequently in the fence line. A mortise for inserting a brace may be made in the upper end by temporarily placing a block of the desired dimensions in the green post. This operation requires considerable skill to prevent ruining the post.

Some persons prefer making an offset or bracket (fig. 9) on the post. Others mold the post and brace together at the same time.

Braces are made and reenforced like line posts. The ends must be molded to a bevel in order to fit the offset or bracket in the post. The wire brace is commonly used, but sudden strains are liable to crack the top of the line post to which the wire is fastened. Another brace between the first and second line posts and slanting in the same direction as the concrete brace will remove such danger. A mass of concrete run around the ground end of the brace will fix it securely.

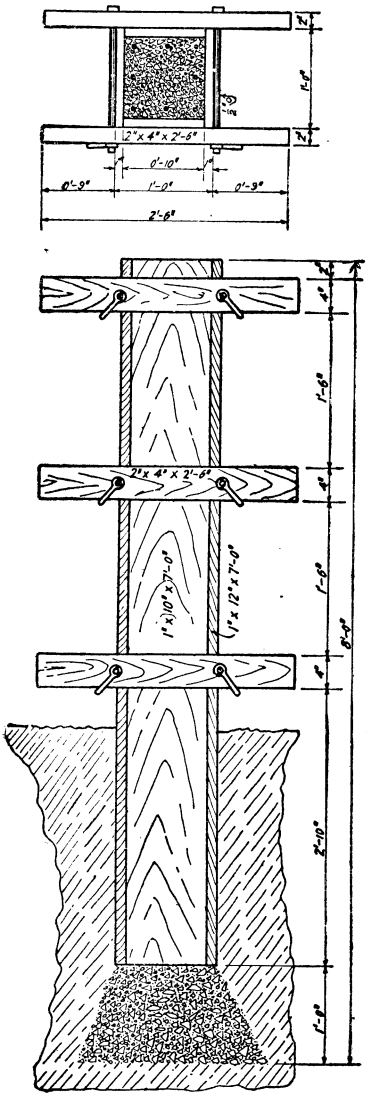

FIG. 9.—Method of constructing brackets for bracing posts.

GATE POSTS AND HITCHING POSTS.

Gate posts are made in the same manner as corner posts. Hanging is accomplished by using a hinge with a clamp strap which entirely encircles the post. Fasteners are attached in the same way. Holes for bolt hinges are sometimes made in the post during the molding. Large iron washers should then be placed between the post and the nut. If a hole is desired for a fastener, the hole should first be made by inserting a piece of gas pipe in the green concrete.

Hitching posts are merely line posts. Wrought-iron clamp straps make better attachments for holding the rings than holes through the post, which weaken it.

VINEYARD AND ARBOR POSTS.

As plenty of gravel is usually found in sections where grapes are grown, concrete posts are very convenient in the culture of grapes. A light line post will serve the purpose. If wire or an iron piece is not used to support the vines, an offset or bracket should be made on the post to hold the cross arm. The cross arm may also be made of

concrete. Some growers prefer to erect a light line fence, using smooth wire from post to post as a means of supporting the vines.

Arbor posts are constructed in the same manner as vineyard posts. The skeleton work may also be made of concrete.

WARNING.

Persons intending to buy post molds, either steel or wooden, are warned to beware of unknown traveling agents who are selling molds, or farm, township, and county rights for the sale or use of their respective molds. Molds should not be purchased from strangers, unless one is fully satisfied through his bankers or attorneys that the company represented by the agent is reliable and that the agent is their true and authorized representative. Often such persons fraudulently claim that the farmer has infringed upon their patent rights by using some feature of their article, and point to some similarity in the two articles as proof of their statement. After a discussion, filled with threats of suits for great damages, the stranger may finally agree, on account of the owner's ignorance of the infringement, to release him from prosecution for a sum of money much less than the damages which he claims he could obtain in court. No such alleged damages should be paid, even if there is a resemblance between the two articles. The matter and the agent should be referred to one's lawyers. This will almost always settle the matter.

As for township, county, and state rights for the sale of articles, it can be depended upon that, if this were such an easy and quick way of getting rich, the agents, despite their statements of lack of time to work the field and the necessity of personal acquaintance, would not dispose of the opportunity to anybody. Above all things, no papers should be signed, and, while cash may be paid for the article, it should be paid only after the article is delivered. A number of patents have been granted on special types of reenforced concrete fence posts. These special types of reenforcement can not, of course, be generally used without danger of infringing patent rights. It is doubtful, however, if any of these special forms of reenforcement present any great advantages over the simple forms of reenforcement described in this bulletin. As far as simple reenforced concrete is concerned, it should be remembered that it has been in common usage in all countries for a great many years, and can not be covered by patent rights. No one need hesitate to use this form of construction, for all claims that the general use of reenforced concrete fence posts is controlled by patent rights are unjustified and untrue.

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